Technical Goals of the Collaboration Infrastructure in US SMTF Deliverables

- Common goals for all projects
- Project specific techncal goals
  - ILC, PD, CW, RIA…others
- Infrastructure in US labs
- SMTF Deliverables
- Conclusions

Establish Overall Infrastructure for all projects

- Establish SMTF Infrastructure in Meson Hall & New Meson for ILC, PD, CW, and RIA Activities
  – Cryomodule test areas
  – Beam test areas
  – Cavity test areas (in later phases)

  – Cryogenics,
    - Phase I & II : 60 W at 2 K initial (refrigerator exists), Additional cryo at 4K
    - Phase III: 300 W at 2 K later, 300 W at 4 K, 5 kW at 40 K
  – RF
    - Phase 1- one 15 MW modulator (B1), one 5 MW klystron
    - Phase 2- one 15 MW modulator (B1), one 10 MW klystron
    - Phase 3- two 15 MW modulators (one new B3), two 10 MW klystrons (one new)
  – Shielding….

SMTF Meson area picture

Meson East & SM12 magnet 20April2005
picture

Also under consideration: New Muon Facing South

picture

ILC - (1) Acquire Cavities and Cryomodules

- Enhance infrastructure for cavity treatment and testing at collaborating institutions, Fermilab and industries.
  - e.g. Jlab EP 9-cell cavities, vert test 9-cell cavities
  - e.g. Complete cavity treatment facility at Argonne/Fermilab
- Establish process for repeatable high performance (35 MV/m, $Q > 10^{10}$) with 9-cell cavities
- Acquire Cavities and cryomodule components for SMTF
  - Fabricate 1.3 GHz high gradient cavities, cavity-strings and prototype cryomodules in collaboration with laboratories, universities and US industrial partners.
  - Acquire DESY cryomodule
- Develop design for 4th generation cryomodule in concert with ILC labs world wide
- Acquire 4th generation cryomodule components, assemble

ILC (2) Cryomodule Assembly and Test

- Establish infrastructure for assembly of prototype cryomodules using cavities or cavity-strings produced at collaborating institutions and industries.
- Acquire, assemble and test RF components
- Establish cryomodule test area in Meson Hall
- Test cryomodules on module test stand

ILC - (3) Beam Tests

- Move FNPL injector to Meson Hall
  - Upgrade Injector
- Test modules with beam
- Demonstrate 1.3 GHz cavity operation at 35 MV/m with beam currents up to 10 mA at a 0.5 % duty factor.
- Measure key performance aspects
  - Long term operation, trip rates, recovery times, dark current, amplitude & phase control, alignment, vibration, input coupler performance, HOM damping…
  - Many long lists, with items to cover R1, R2, R3 and R4

More Detail : Technology Studies

- Determine the maximum operating gradient of each cavity & its limitations.
- Evaluate gradient spread and its operational implications.
- Measure dark currents, cryogenic load, dark current propagation, and radiation levels.
- Measure alignment of the quadrupole, cavities and BPM in-situ using conventional techniques (e.g. wire or optical).
- Measure vibration spectra of the cryomodule components, especially the quadrupolemagnet.
- Measure system trip rates and recovery times to assess availability.
- Develop LLRF exception handling software to automate system and reduce downtime.
- Evaluate failures with long recovery times: vacuum, tuners, piezocontrollers, and couplers.

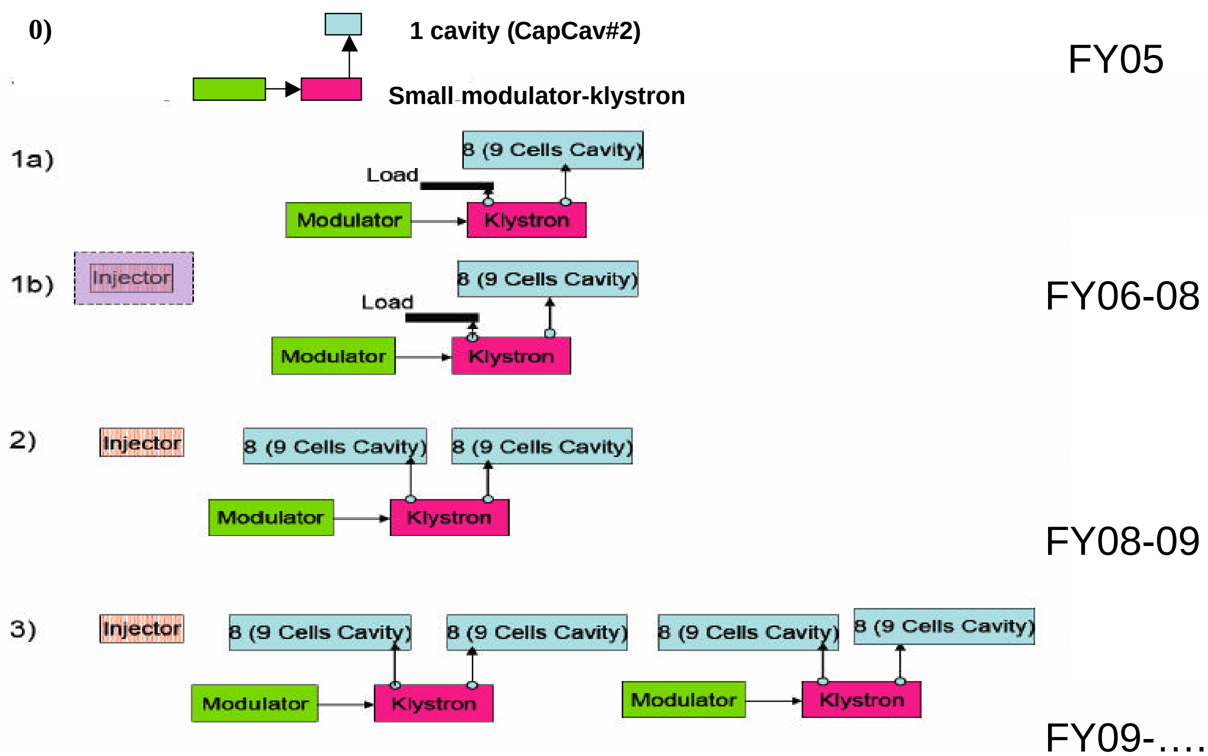
More Detail : Physics Measurements

- Beam energy:a spectrometer would provide an independent and accurate measurement of the accelerating gradient (rf based techniques are not as accurate).
- Long-range wake-field characterization:Measure frequency spectra of bunch positions downstream of cryomodule to search for high Q cavity dipole modes that could cause beam break-up in the ILC. Correlate these data with HOM power measurements.
- Tests of low-level rf system:demonstrate that a < 0.1% bunch-to-bunch energy spread can be achieved in a 1 msecbunch train.
- Impact of the SCRF cavity on transverse beam dynamics: measure the beam kicks caused by the fundamental mode fields.
- Study beam centering based on HOM dipole signals.

ILC - (3)

- Develop industrial production capability
- Work with industry to reduce costs
- Warren will discuss possible paths

Phases of SMTF Beta=1 Modules



Proton Driver

- The Proton Driver is an 8 GeV SCRF proton linac
  - For Neutrino Super-Beams & other new capabilities at FNAL
- The last 85% of the PD linac (1 GeV to 8 GeV) is *identical to the ILC.*
- Thus, R&D program for the *back end* of the Proton Driver is identical to the ILC SMTF synergy.
- R&D for the *front end* of the PD extends technology of SNS, RIA, JPARC, ILC, and other projects.

PD

- Establish area for high power, 325 MHz, testing of $\beta < 1$ accelerator structures in pulsed mode (~1% duty factor).
- Fabricate test structures and associated cryomodules
  - 325 MHz cavities in various beta ranges
    $\beta = 0.47$ and 0.61, 1300 MHz elliptical cavities
- The Proton Driver also uses β=1, 1.3 GHz cavities cryomodules that are nearly identical ILC.
  - Demonstrate operation of 1.3 GHz cavities and module at 27 MV/m with beam currents up to 8 mA at 0.75 % duty factor with multiple cavities being driven by one klystron using fast ferrite phase shifters.
- Demonstrate 1.3 GHz, $\beta \sim 0.5$-0.8, elliptical cavity operation at > 15 MV/m at $Q > 5x\ 10^9$ and a 1% duty factor with multiple cavities being driven by one klystron using fast ferrite phase shifters.
- Demonstrate high gradient operation in pulsed mode of 325 MHz, $\beta < 1$ cavities and cryomodules.
- Demonstrate individual cavity resonance control with multiple cavities driven from one klystron, using fast ferrite phase shifters, at both 1.3 GHz and 325MHz
- Prototype new generation modulators
  - 3 ms pulse width beam pulse, rf pulse 4.5 ms
- Need time scale plan for building and testing

CW for Future Light Sources

- Establish a beam test area using β=1 pulsed test beam.
- Fabricate high Q accelerating cavities and cryomodules
- Fabricate deflecting cavities and cryomodules
  - Also supports ILC crab cavity development elsewhere.
- Demonstrate 20 MV/m CW cavity operation with Q values of ~ $3x10^{10}$ with associated RF controls.
- Demonstrate wakefield suppression,. HOM absorbers
- Solve heat load management
- High stability and control of accelerating fields, goals of phase error < 0.01° and amplitude error $<10^{-4}$
- Demonstrate deflecting cavities at transverse kick voltage of 5 MV/m, and $Q_o > 5x10^9$
  - HOM (higher-order modes) and LOM (lower-order modes) damping validation, polarization control

.

RIA

- The U.S. Rare Isotope Accelerator Project will include the construction of nearly 500 superconducting cavities of as many as 10 different types to accelerate ions over a velocity range $0.02 < \beta < 0.85$.
- Cavity types, cryomodules, couplers, and tuners are similar in design to PD

RIA

- Spokes are well developed technology but not tested with high power and not tested with beam
- Expand on-going RIA work
- Bare cavity tests, string assembly, module assembly
- ##Example resonator that needs to be developed
  - Improved design.
- Test modules
- First beam tests with significant beams via PD front end
- Higher power couplers than before

Accelerator Physics R&D

- Construct and operate the improved photo-injector
- ##Parameter Table of existing injector /compared to Table for upgraded injector/ILC parameters needed
- Beam test modules
- Long range and short range wakes, HOM load performance..
- 1 GeV upgrade injector would provide beam parameters similar to ILC injector useful for optimization studies
- Produce positrons, study beam dynamics of positron source, capture, matching, optimization
- R&D on beam instrumentation, beam diagnostics
- Train accelerator scientists.

Supporting SRF R&D

- High gradient and high Q R&D
  - Understand and improve processing steps
- Material research to improve cavity performance.
- In collaboration with partners
  - Applied Superconductivity Center, Wisconsin, Northwestern University
- Important R&D not pursued elsewhere
  - Dynamics of magnetic flux penetration into superconductors
  - Atom by atom analysis of niobium surface from oxide, to oxide interface, to metal

Existing Facilities

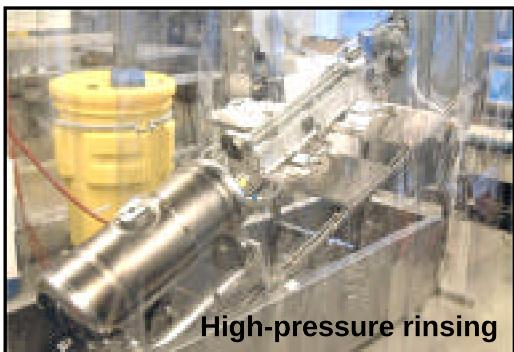
- Substantial facilities exist in US for
  - Cavity fabrication, preparation and testing
  - Cavity string and cryomodule assembly and testing
- Argonne, Cornell, Fermilab, Jlab, LANL,MSU
- These facilities will need enhancement to deal with challenges of
  - ILC level high performance
  - Support development of US industrial base
  - Large Scale Industrialization

Argonne

Phase I: The Joint ANL/FNAL Chemistry Facility

- **Two sealed chemistry areas, 16 ft ceiling**
- **Large air scrubber suitable for RIA cavity production**

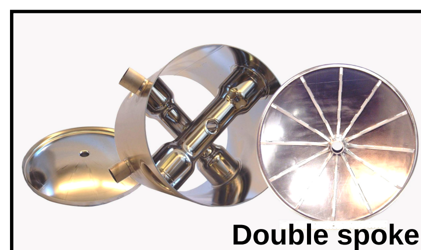
Techniques: Clean Processing for SRF Cavities


High-pressure rinsing


Clean room cavity assembly


Quarter-wave

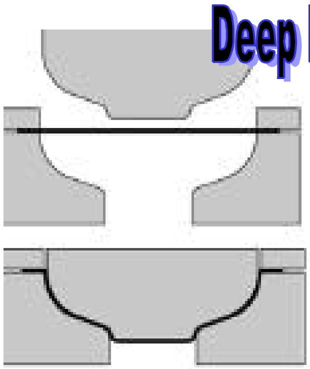

Co-axial half-wave


Double spoke

Cornell

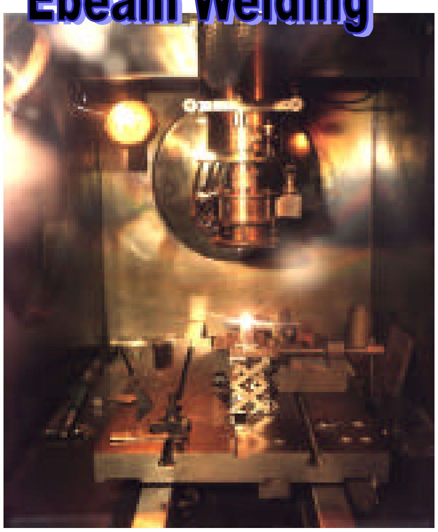
SRF Infrastructure

Deep Drawing



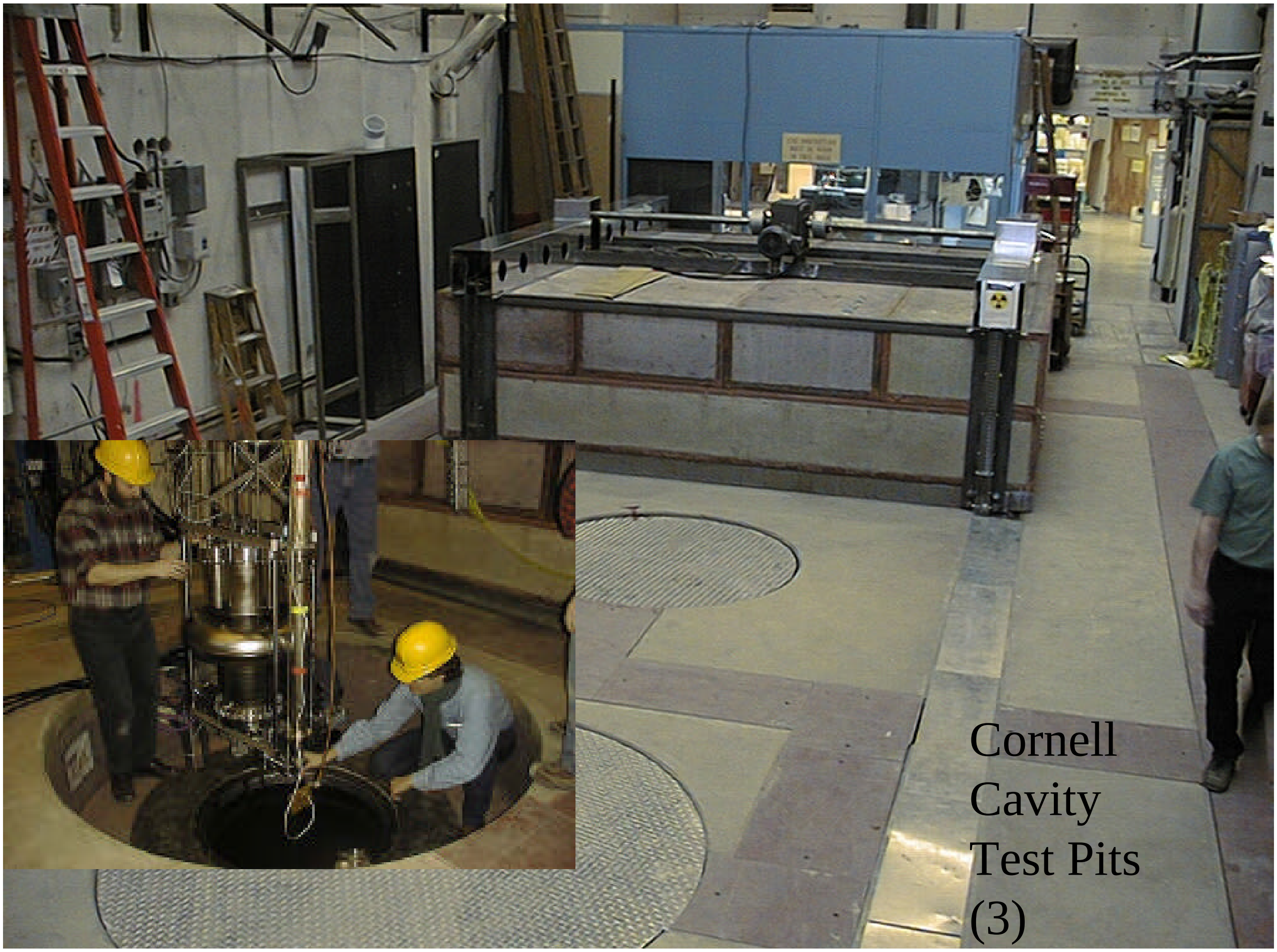
1000 Sq Ft Clean Room

Ebeam Welding



Chemical Etching

High Pressure Rinsing



Cornell
Cavity
Test Pits
(3)

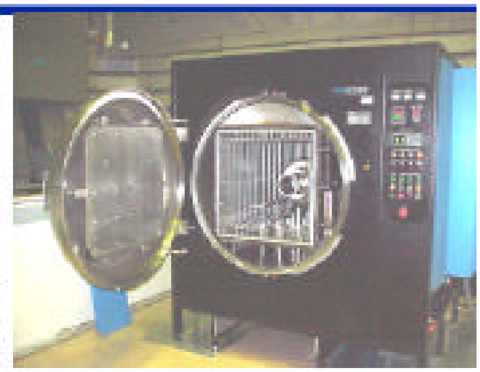
Test Stand Ready for 9-cells

Jlab

Production Facilities – Cavities

Deep Drawing Press

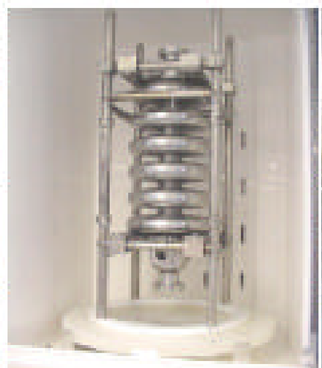
Electron Beam Welder



1250°C Vacuum Oven

Closed Chemistry Cabinet

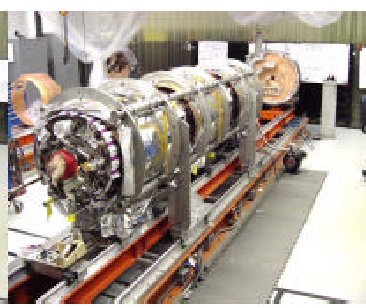
Electropolish Cabinet

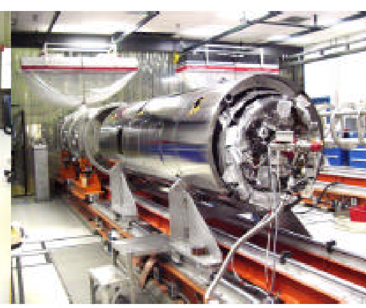


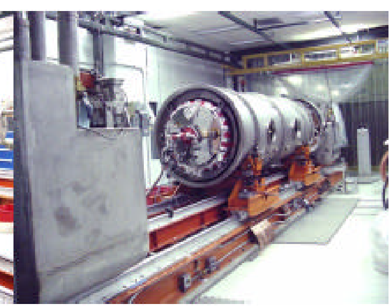
Hi Pressure Rinse Cabinet

Class 100 & 10 Clean Rooms

Production Facilities – Cryomodules

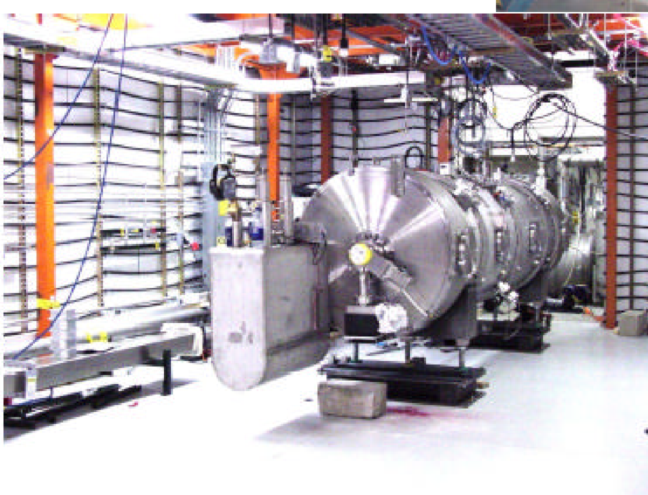






Production Facilities - Testing

- VTA has 500 W cw sources at 805 and 1497 MHz
- CMTF has 20 kW 805 MHz cw source and 16 kW 1497 MHz cw source



LANL

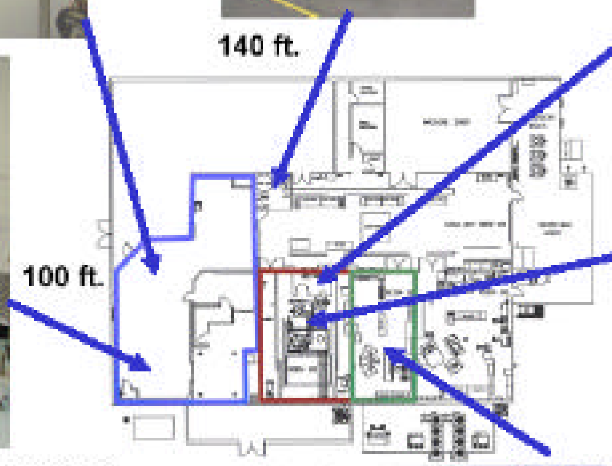
Facilities at the SRF Lab

2600 ft² class-100 Clean room, 10-ft high

Ultra-pure water with 2000 G/day and 1500 G storage tank

cryostat inserts

High-pressure rinse in a clean room.



Building MPF-17

Cryostats with movable radian shield

Control, tuning

This 2,600 ft^2 (260 m^2) clean room

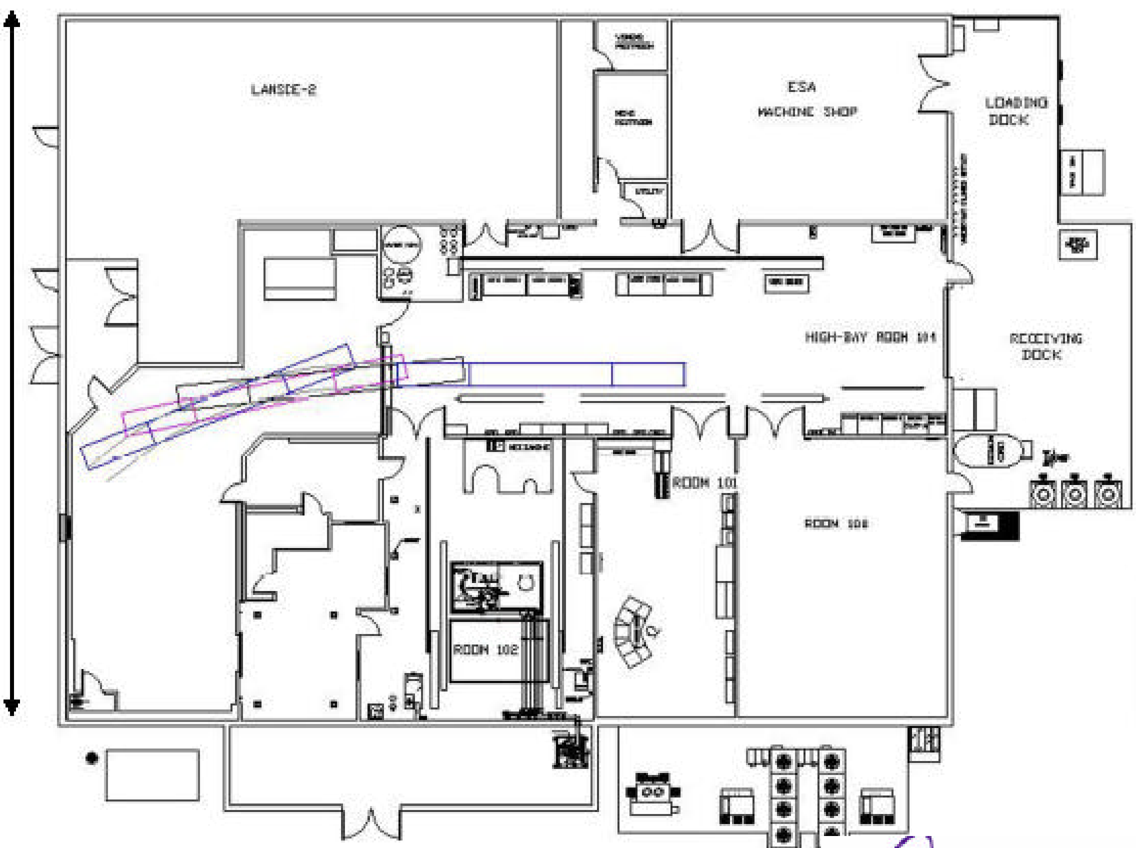
Los Alamos

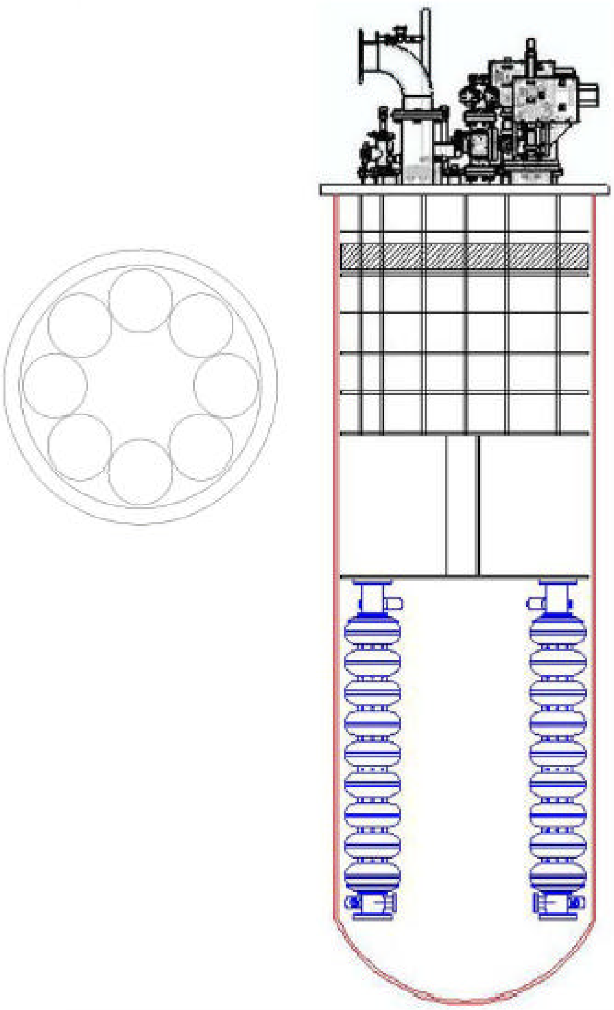
38-inch (~1m) diameter, 10-ft (~3m) deep cryostat with radiation shield

industrialization

43m

30m



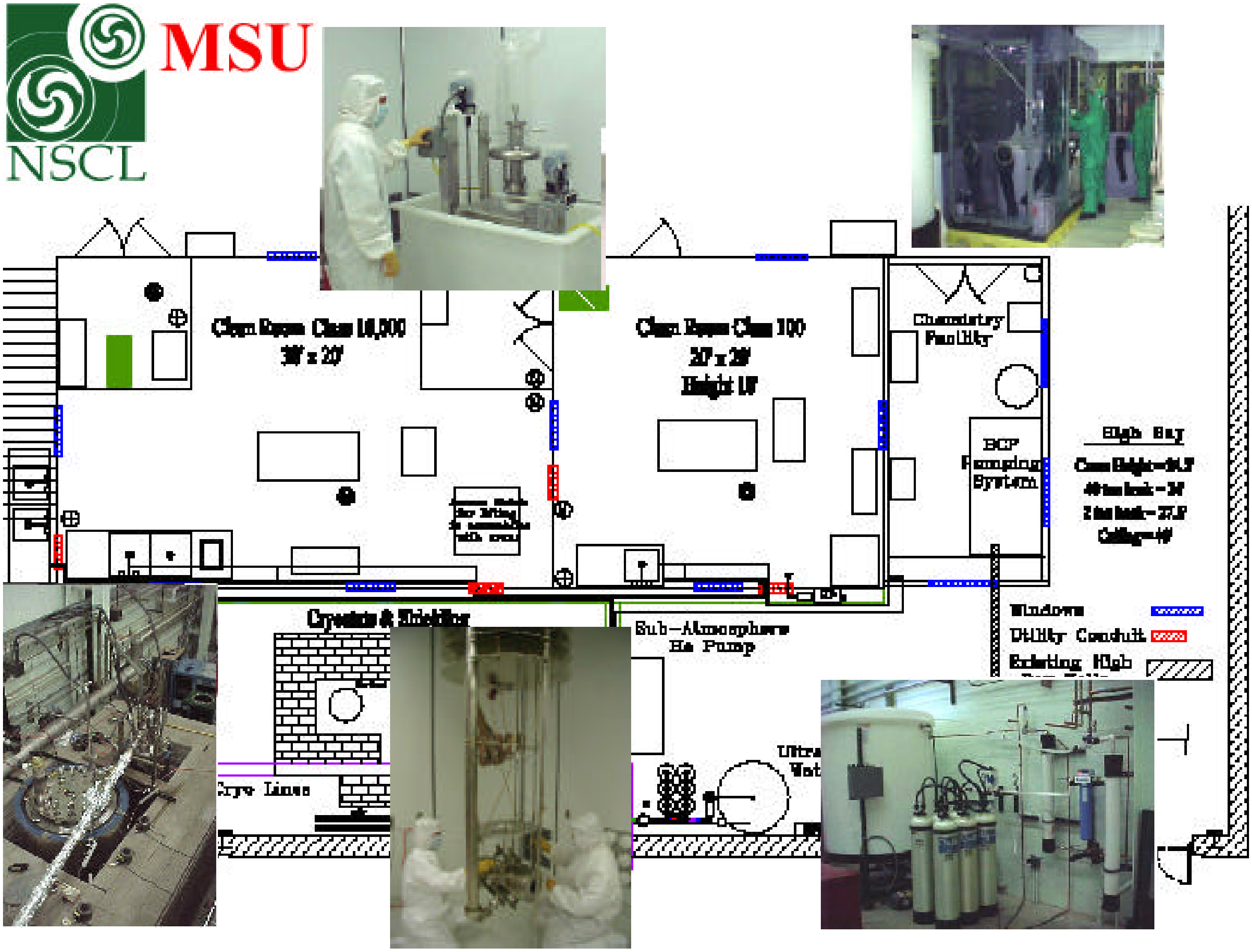


Existing vertical cryostat with 8 TESLA 9-cell cavities in it, which enables us to test 8 cavities by filling the cryostat with liquid helium only once

MSU

MSU

NSCL



Clean Room Class 10,000
Clean Room Class 100
Chemistry Facility
BCP Pumping System
High Bay
Windows
Utility Conduit
Sub-Atmosphere He Pump
Cryo Lines

Deliverables

- Repeatable process for 35 MV/m, high gradient, high Q, 9-cell cavities
- US - ILC 8-cavity cryomodule
- 4th generation cryomodule
- R1, R2 cavity, cryomodule and beam test goals
- 3rd harmonic cavities for injector
- Deflecting cavity for beam diagnostics and crab
- Fast ferrite based tuner for ILC
  - Match cavity to gradient
  - Improve coupler conditioning times

Conclusions

- Several ambitious SRF-based accelerator projects are planned in US
  - International Linear Collider, Light sources, RIA, PD
- SMTF will expand existing srf expertise at: Argonne, Cornell, Fermilab Jefferson Lab, MSU
- SM&TF will provide:
  - a facility where different module types & linac systems can be tested (beam)
  - a collaboration on cold linac technology, module development & fabrication
- SM&TF will allow US to:
  - –Take advantage of advances in technology to extend science goals
  - –Pursue potential of SRF
  - –Minimize cost of new projects by using most advanced SRF methods
  - –Build cooperation with industry
- –Collaborate with Europe and Asia
- Overlap of national experts at one facility will allow exchange of ideas and thus unify US approach to SRF-for more effective use of resources
- Build collaboration to prepare/plan to host ILC & build fraction of linac in US (under direction of ILC- GDE)